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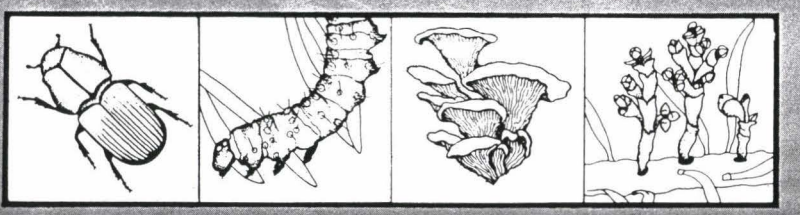

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RHIZOSPHAERA NEEDLECAST OF COLORADO BLUE SPRUCE IN NORTHERN IDAHO

by

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and

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ABSTRACT

Needlecast of Colorado blue spruce trees in a plantation near Sandpoint, Idaho was caused by the fungus *Rhizosphaera kalkhoffii*. Seedlings for the plantation were originally grown at a northern Idaho nursery. Symptoms on affected trees included purple-brown foliar discoloration, particularly concentrated near the base of trees. After incubation in moist chambers, black fruiting bodies (pycnidia) protruded through stomata on the under needle surfaces. Pycnidial and conidial morphology were as described for *R. kalkhoffii*. This is the first report of this fungus in Idaho. Procedures for reducing damage in nurseries and plantations are discussed.

INTRODUCTION

During April 1992, several samples of Colorado blue spruce (*Picea pungens* Engel.) were received from the University of Idaho Extension Center in Sandpoint, Idaho. These samples were collected from a northern Idaho plantation. Seedlings for this plantation had been 2+0 stock produced by a nearby nursery.

The affected plantation contained two groups of stock: trees outplanted on the site for 9 years and others outplanted for only 2 years. Needles on younger trees had purple-brown discoloration, primarily concentrated near their lower crown. Older trees had general chlorotic foliage and definitive branch tip dieback.

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METHODS

Purple-brown needles from younger trees were detached from branches and examined under the binocular microscope for presence of fruiting structures of potential pathogenic fungi. Discolored needles were also washed thoroughly under tap water, placed in moist chambers, and incubated 3-5 days at about 24°C under diurnal cycles of fluorescent light. Chlorotic foliage and necrotic branch tips from older trees were also examined and placed in moist chambers to induce sporulation of associated fungi. Fungi arising from discolored needles or necrotic branch tips were examined and identified using standard taxonomic guides (Barnett and Hunter 1972; Sutton 1980).

RESULTS AND DISCUSSION

The most common fungus associated with purple-brown discolored needles was *Rhizosphaera kalkhoffii* Budak. This fungus produced black fruiting bodies (pycnidia) that erupted through stomata lining the undersurfaces of infected needles (figure 1). At the tip of pycnidia, white deposits were readily apparent (figure 1); these deposits were exudations of conidia. Pycnidia were localized within specific zones along needles, with non-pycnidial zones interspersed. Microscopic examinations of conidia revealed they were hyaline, one-celled, with large vacuoles, and measured approximately 6-8μ x 3-5μ. Pycnidia were largely superficial on needles, produced above stomata. They were globose, thin-walled, lacked conidiophores, and connected to the substrate by a hypostoma. The ostiolar opening was centrally located and opened widely to release conidia. These pycnidial and conidial characteristics corresponded to taxonomic descriptions of *R. kalkhoffii* (Sutton 1980; Waterman 1947).

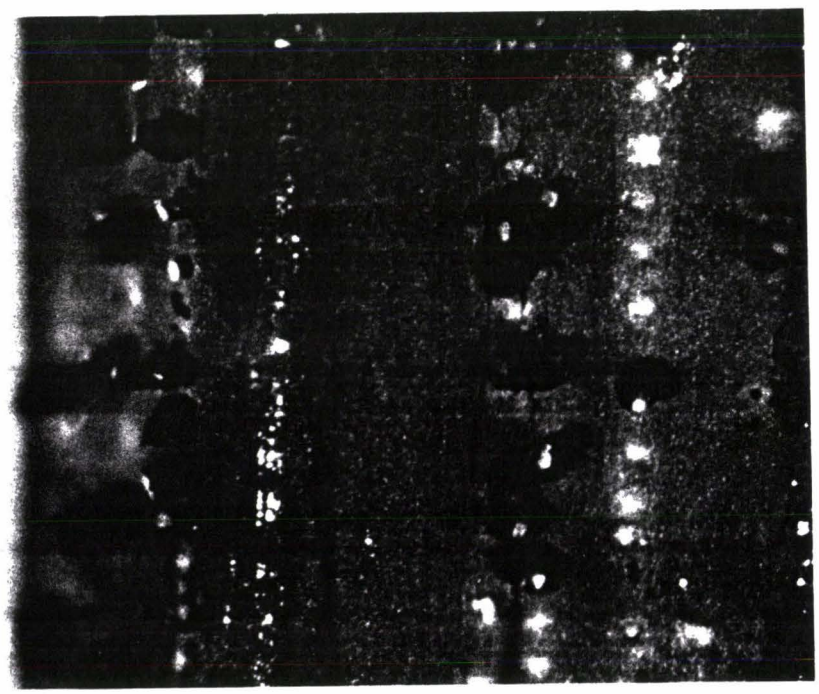

Figure 1--Pycnidia of *Rhizosphaera kalkhoffii* erupting through stomata on the undersurfaces of Colorado blue spruce needles from a Christmas tree plantation near Sandpoint, Idaho.

Examinations of necrotic branch tissues failed to reveal presence of potentially pathogenic fungi. For example, *Sirococcus strobilinus* Preuss, which often causes dieback symptoms on several conifer species and suspected as being present, was absent on the spruce samples examined. *Rhizosphaera* likewise was not found on chlorotic foliage, but was limited to purple-brown foliage. Therefore, it appears that *R. kalkhoffii* was primarily responsible for purple-brown discoloration of needles, but not involved in branch tip dieback. Branch

dieback of spruce in Europe was initially thought to be associated with *R. kalkhoffii*; however, after several years of investigation, neither this nor any other fungus was associated with branch dieback in the tops of affected Norway spruce (*Picea abies* (L.) Karst.) (Diamandis 1978, 1979b). The problem was related mostly to water stress in affected parts of trees (Diamandis 1979b). Since branch dieback can be caused by many things, it is often difficult to determine etiology if suspected pathogenic fungi are not found. Abiotic factors, such as reponses to fertilizers or herbicides may have been involved in branch dieback.

This is the first report of *R. kalkhoffii* in Idaho, although it may previously have existed in the State. This needlecast fungus was first reported in the United States in 1938 on ornamental blue spruce trees in Connecticut (Waterman 1947). It has since been detected in New York, Massachusetts, Vermont, Pennsylvania, Virginia and North Carolina (Shriner and Grand 1974), and causing severe problems in Wisconsin, Michigan, Minnesota, and Indiana (Farr and others 1989; Skilling and Walla 1986). *Rhizosphaera kalkhoffii* has also been reported in North Dakota and South Dakota (Skilling and Walla 1986), Arizona (Hawksworth and Staley 1968), and Colorado (Hawksworth and Staley 1978). This fungus has been reported in British Columbia on species of *Abies*, *Pinus* and *Pseudotsuga* (Funk 1985); it also occurs in Oregon and Washington at moderate levels (J. Stone, personal communication). This fungus also occurs in other parts of Canada (Quebec and New Brunswick)(Skilling and Walla 1986) and is common in Europe (Diamandis 1979a; Dotzler 1991; Kumi and Lang 1979; Sutton 1980; Wilson and Waldie 1926) and Japan (Chiba and Tanaka 1968).

Rhizosphaera kalkhoffii is an important pathogen of blue spruce (Waterman 1947). On other spruce and conifer species, the fungus is less damaging and may even be saprophytic (Diamandis 1979a; Dotzler 1991; Kumi and Lang 1979; Tanaka and Chiba 1971; Sutton 1980). Pathogenicity testing has been rare, but recent work by Juzwik (1993) indicated certain strains can be quite virulent on several spruce species. Therefore, there may be differences in pathogenicity levels among strains of the fungus as well as differences in host species susceptibility (Juzwik 1993; Kumi and Lang 1979).

Biology of *R. kalkhoffii* within blue spruce plantations has been fairly well documented, particularly in the Lake States and Pennsylvania. It is possible that some biological aspects may vary in Idaho and further research is necessary to evaluate differences or similarities. The pathogen is usually introduced into plantations on infected nursery stock (Nicholls and others 1974; Shriner and Grand 1979). This has allowed for long-distance spread of the pathogen in several eastern states (Nicholls and others 1974). Since the life cycle of the fungus usually takes 2 years to complete (Skilling and Walla 1986; Waterman 1947), it is likely nursery stock becomes infected during its first growing season. Conidia are dispersed only via rain or water splash (Skilling and Walla 1986); therefore, long-distance natural spread may be restricted. Infected ornamental spruce surrounding nursery beds may be an important inoculum source in nurseries (Skilling and Nicholls 1974). It is also possible that nursery equipment (tractors, spray rigs, etc.) might disseminate spores within nurseries (Skilling and Nicholls 1974; Skilling and Walla 1986). However, little is known about epidemiology of the fungus in nurseries.

Once *R. kalkhoffii* is introduced into plantations, it usually spreads from individual foci (Nicholls and others 1974). Within infected trees, the fungus is usually found initially at the bottom of the crown. In subsequent years, it moves up through the crown increasing defoliation (Skilling and Nicholls 1974; Waterman 1947). Branches defoliated for three or more consecutive years may die (Nicholls and others 1974; Skilling and Walla 1986). Infection usually occurs by condia in late spring and is confined to young needles (Skilling and Walla 1986; Waterman 1947). Symptoms are usually not produced until the following spring, when infected needles turn purple-brown. They may then produce mature pycnidia during the spring or early summer. Conidial release coincides with development of new foliage on host trees. In some cases, infected 2-year needles may remain on branches throughout the summer and fall. However, much needle loss occurs the second year following infection (Nicholls and others 1974; Skilling and Nicholls 1974; Skilling and Walla 1986).

This general disease cycle applies throughout most of the range of *R. kalkhoffii* in the U.S. However, Merrill and Kistler (1978) described a variation of the disease cycle on blue spruce in central Pennsylvania. They found that most infected needles turn chlorotic and then purple-red as early as mid-August of the first year following infection. These needles gradually turn purple-brown and the fungus sporulates on them while still

attached to the tree from August to November of the first year. These infected needles are cast during the fall and winter. They also found initial infection may occur at any height on a tree, but most frequently occurs from 1-2 m above ground. Once infection has occurred, spread of the pathogen within a tree is downward and sideways in a cone-shaped pattern, corresponding to the dissemination pattern of rain-splashed conidia. This symptom pattern creates holes in the sides of densely sheared Christmas trees. Their work described both spring and fall infection of blue spruce in central Pennsylvania.

Disease epidemiology in northern Idaho has not been investigated. Until such investigations are completed, it is probably best to expect spring infection and symptom development as described for most of the range of the disease in the U.S. Therefore, disease control efforts should probably be concentrated in the late spring when infection is expected.

DISEASE MANAGEMENT

Management of needlecast caused by *R. kalkhoffii* is usually required in high-value plantations such as Christmas trees (Skilling and Nicholls 1974). The best way to reduce damage is by preventing introduction of the pathogen into plantations in the first place (Skilling and Walla 1986). This may be accomplished by carefully examining nursery stock and destroying seedlings with disease symptoms, particularly those with purple-brown foliage and evidence of fungal sporulation (Skilling and Walla 1986). Planting susceptible blue spruce seedlings near ornamental spruce trees is not recommended due to possibilities of fungal movement from ornamentals (Skilling and Nicholls 1974).

Once the pathogen is intoduced into plantations, control is more difficult. It is possible that fungus spores may be mechanically moved from tree to tree on shears or workers (Nicholls and Skilling 1974; Skilling and Nicholls 1974; Skilling and Walla 1986). Therefore, it is recommended to avoid shearing when foliage is wet (and the fungus is sporulating), or that shearing be done first on trees without disease symptoms. This will help prevent disseminating the fungus from infected to non-infected trees. Sterilization of shearing equipment with alcohol or bleach solutions between trees may also be useful (Skilling and Nicholls 1974).

Fortunately, *R. kalkhoffii* is rather easily controlled by fungicide applications (Waterman 1947). Several reports (Nicholls and others 1974; Skilling and Nicholls 1974; Skilling and Waddell 1975; Skilling and Walla 1986) indicate the disease can be adequately controlled by two fungicide applications in the late spring (early June and either late June or early July). Chemicals shown to be efficaceous against *R. kalkhoffii* include Bordeaux mixture, chlorothalonil, and benomyl (Skilling and Waddell 1975; Skilling and Walla 1986; Waterman 1947). Applications of fungicides for 2-3 years may be sufficient to "cure" infected trees, i.e., damaged foliage may not be noticeable after several fungicide treatments (Skilling and Walla 1986).

Even though fungicides are effective in disease control, the best approach to long-term control is still prevention. It is unknown how or when *R. kalkhoffii* was introduced into northern Idaho. Extent of its distribution on nursery stock or ornamental and Christmas trees is also unknown. Likewise, we do not know its host range, i.e., if or to what level it may infect native Engelmann spruce (*Picea englemanni* Parry). However, it is likely the cool, wet spring weather that often occurs in northern Idaho is conducive to infection and buildup of this pathogen. Therefore, if the fungus is introduced into plantations via infected nursery stock or other mechanical means, its importance could greatly increase in the future. Of particular concern are the large number of blue spruce plantations in northern Idaho. Care should be taken to adequately examine nursery stock to ensure that it is not infected prior to planting. Surveys of blue spruce plantations are also warranted, since this is a very popular ornamental species. With better information on distribution and importance of *R. kalkhoffii* in northern Idaho and adjacent states, more effective efforts may be initiated to restrict its spread and limit its potential damage.

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